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Creating Serious Games at Third Level: Evaluating the Implications of an In-house Approach

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Abstract: Due to the inherently interdisciplinary nature of serious games their development necessitates the effective collaboration of team members spanning multiple disciplines and skill sets (Adams 2010). In their attempts to harness these skills, most higher education projects have formed teams through academic/commercial partnerships, whereby academics and commercial developers combine their respective expertises in subject matter/pedagogy and game design/development. However considering the expertise in most higher education institutions and the recent surge in serious games courses at third level, one might reasonably conclude that higher education holds huge potential for developing serious games in-house. Yet surprisingly, such ventures are relatively few. Thus, while cross-faculty higher education collaborations may hold potential for developing serious games, the implications of such an approach are largely unexplored to date.

This paper aims to remediate this gap in the literature by presenting a phenomenological, naturalistic case study of an innovative project based in one higher education institution which involved multiple disciplines in the design and development of a serious game. Using a theoretical framework for game design comprising the elements of play, pedagogy and fidelity, this paper examines the impact of an interdisciplinary in-house approach on the design of this serious game, paying particular attention to the balancing of design elements and the impact of disciplinary perspectives in this regard. As such this study adds a new dimension to established difficulties involved in serious game design by illustrating the significant impact which interdisciplinary team work practices, and associated disciplinary perspectives, can have on the design process and product.

Keywords: Case study, game design, disciplinary perspectives, collaboration, partnership, higher education

1. Introduction

Due to the inherently interdisciplinary nature of serious games, their development necessitates the effective collaboration of team members spanning multiple disciplines and skill sets (Adams 2010). In their attempts to harness these skills, most higher education (HE) projects have formed teams through academic/commercial partnerships. However considering the expertise in most institutions and the recent surge in serious games courses at third level, one might conclude that HE holds huge potential for developing serious games in-house. Yet surprisingly, such ventures are relatively few.

This paper aims to remediate this gap by evaluating an innovative project based in one HE institution which involved multiple disciplines in the design and development of a serious game. Using a theoretical framework for game design comprising the elements of play, pedagogy and fidelity, this paper examines the impact of an interdisciplinary in-house approach on game design, paying particular attention to the balancing of these elements and the impact of disciplinary perspectives in this regard.

The paper begins by providing a contextual backdrop to the project, outlining its origins and contributors. It then introduces the theoretical framework which informed the design of the project, and which was used as a lens by which to analyse the impact of disciplinary perspectives on the design process and product. Attention then shifts to evaluating the process and product of serious game design in this project: in this regard, the influence of participants' disciplinary backgrounds and perspectives and their impact on balancing of elements in the game design is explored. The paper concludes by reflecting on the project and exploring implications for developing serious games in the HE sector.

2. A triadic framework for serious game design – play, pedagogy and fidelity

With serious games, most experts argue that achieving an effective balance of play and pedagogy is key to their effectiveness (Seeney and Routledge 2009). While a sound pedagogical basis is considered essential to their effectiveness as learning tools, equally important is the integration of *play* elements which harness and sustain player engagement. Additionally, with the advent of sophisticated and immersive technologies, as exemplified in the virtual worlds of contemporary games, and increasing interest in the opportunities for constructivist learning offered by these worlds, concepts of fidelity, and its impact on student learning and engagement, have emerged (Aldrich 2005).

While previous research has highlighted the difficulties involved in balancing these components in serious game design (Harteveld 2011), frameworks for achieving an effective balance remain elusive. In particular, the impact of contrasting disciplinary perspectives and practices on the balancing of these components has remained largely unexplored. The sections that follow aim to remediate this gap by analysing the impact of disciplinary perspectives on the balancing of play, pedagogy and fidelity in one serious game.

3. The project: origins, stake-holders and contributors

The project which forms the basis of this study was initiated by a lecturer (henceforth referred to as Enda[1]) who was interested in producing a simulation to teach the principles of food safety and environmental health to undergraduates. Preliminary research had shown that while educational gaming endeavours in this discipline had been attempted previously — for example *Siqur* (www.siqur.com) and *Science Pirates* (www.sciencepirates.org) — an immersive game which met Enda's pedagogical objectives did not exist.

After extensive collaboration and consultation, a multidisciplinary team was formed comprising staff and students from within the institute. Two undergraduate computer science students (Dan and Dom) were employed full-time during the summer break to work as game developers: they were supported by staff including two elearning developers with expertise in pedagogical design and elearning (myself and Eleanor), one food science lecturer with expertise in food safety education (Enda) and three computer science lecturers with experience in game design and development (Conn, Cain and Colin). (See figure 13.)

The benefits of taking a multidisciplinary in-house approach were quickly recognised. While giving students valuable work experience, it also gave staff the opportunity to work on serious game design and development from the ground up, helping them understand the process and underpinning design strategies. In this way, it was hoped that the project would lead to a sustainable model of in-house development which could be adapted across disciplines in the future.

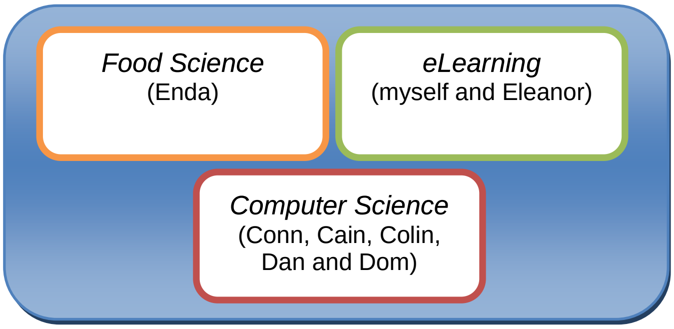

Figure 1. Members and disciplinary backgrounds of the project team

The project was scheduled to last ten weeks, taking place during the summer period. At the end of this period it was envisaged that the team would have created a serious game prototype which could be used and evaluated by undergraduate students and which would form the basis of future development work.

[1] Note that pseudonyms are used throughout this paper for ethical reasons.

4. The design process: balancing play, pedagogy and fidelity

This section describes, in an interpretive narrative style, key events and themes that emerged during the project cycle, providing an insight into the rationale underpinning the game design and the impact of disciplinary perspectives in this regard.

4.1 Selecting a development platform

A development platform was selected by the technical branch of the team based on discussions with Enda regarding his pedagogical objectives for the game. Originally, he had envisaged the creation of a "virtual reality" which simulated the real world as closely as possible, both graphically and in terms of actions and consequences. Realising that the development of a virtual world was not feasible within the constraints of this project, Conn, Cain and Colin decided that a more favourable option would be to use an existing game engine, namely that used to create Valve's *Half Life 2* (www.halflife2.com) — see figure 2 — using the game *Counter Strike Source* as the basis for modification.

Figure 2. Image from Half Life 2

4.2 Formulating a pedagogical strategy

One of the first tasks facing the team was to establish a design strategy for the game. The pedagogical strategy for the game was largely determined by Enda's vision for the project:

> One of the difficulties...is that you can't show students a lot of the things you'd like to because it would be either dangerous or people just won't show you bad practice or it would be….libelous. We thought that if we could create *a virtual environment* that we could lace with all sorts of hazards [] we could rate their ability to pick them out.. and ..issue appropriate recommendations.

Drawing on the theories of situated learning, problem-based learning and experiential learning, and using sophisticated three-dimensional (3D) technologies, Enda, Eleanor and I aimed to create an "authentic" virtual environment — which replicates real-life situations — where students could construct food safety knowledge and develop critical skills. Enda was concerned that students would be able to transfer knowledge/skills from the game world to the real. To maximise transfer, he was keen that the game should mirror the real world as closely as possible. Essentially he wanted to create a 'high-fidelity simulation' (Thiagarajan 1998, cited in Squire 2004 p.31) — which captures every interaction of a system in a physical manner that is consist with their real-world analogs.

This high fidelity approach fitted with Dan and Dom's interests in showcasing the visual features of the game world. However after initial discussions, Eleanor and I were concerned that the development focus should shift from game features to educational underpinnings: as a result we recommended creating learning objectives — taken from the Food Safety Authority of Ireland (2006) — to underpin the game design. Throughout team brainstorming Eleanor and I pushed the learning objectives as the stimuli for the activities and interactions. However, it felt that there were continuing tensions between our educational focus and the technical focus of Dan and Dom, which appeared to prioritise showcasing advanced technical features

> Its hard to just focus on getting the overall picture done first and then worrying about the details, especially when that stair railing could be aligned just a hair closer….

Achieving a balance between exploiting the technology and maintaining an educational focus felt difficult. I wondered if, by constantly pulling them back to the underpinning learning objectives, we were inhibiting their creativity and enthusiasm.

4.3 Formulating a play strategy

Having decided on a pedagogical framework, the next step was to decide on a game design or "play" strategy: a strategy which was informed by Enda's "fidelity" requirements and the development platform. This platform ensured that we were now working with a highly realistic 3D virtual world, and it meant that the game would be in single player mode. Enda was happy with this and it also fitted with the "techies" interests of exploiting the technologies and achieving perceptual immersion by simulating visual reality as closely as possible.

Our next task was to design a game narrative. We agreed that a linear narrative seemed more feasible, given time constraints. Via extensive brainstorming, we created a series of six "missions", each underpinned by at least one learning objective (figure 3). Working these into the beginnings of a storyline, we settled on the following narrative structure: the player arrives at a restaurant on their first day working as a kitchen porter and negotiates various tasks. To accommodate the learning objectives, the player's role changes during the course of the game from kitchen porter to commis chef. Although this change did not strictly adhere to reality, we agreed that it was necessary if we were to cover the learning objectives, and we surmised that it would not significantly compromise the believability of the game. Instead of maintaining virtual fidelity at all costs, we agreed that the emphasis should be on designing engaging activities which would allow students to practice problem-solving, acquire knowledge and become immersed in game play.

	Task/Mission	**Learning objective**
1.0	Wash hands properly using soap provided in dispenser. Dry hands properly using paper hand towels provided.	**Stage 1 Skill 2:** Maintain a high standard of hand-washing. **Subskill:** • Wash hands before starting or recommencing work. • Wash hands using the correct procedure. • Take appropriate action if hot water, soap etc. are not available.

Figure 3. Sample mapping of game missions to learning objectives

In order to provide essential orientation information and feedback, and to enhance the realism of the virtual world, we created several non-player characters (NPCs) including a head chef who accompanies the player throughout. This fitted with Enda's notions of fidelity and, from the perspective of Eleanor and I, also provided scaffolding throughout the game. We also felt (as did Dan and Dom) that interacting with such NPCs would lend a more realistic and engaging atmosphere to the game. As an additional support, we created 'micronarratives' ('localised incidents' in the game background) and information pop-ups on key items (Jenkins 2004, p.6). Finally we began sketching the physical environment of the game. In doing so, we were conscious of Enda's objective of visually simulating reality and we were aware that the game setting would provide an important backdrop to each mission. From a pedagogical perspective it offered opportunities to provide additional scaffolding. From a play perspective, it offered opportunities to stimulate players' curiosity and desire to explore. So, for example, by placing posters on the walls (figure 4), we hoped to facilitate incidental learning of standard food safety practices.

Figure 4. An environmental "hook" utilised in Serious Gordon.

4.4 Replicating reality: virtual fidelity versus usability

Enda was keen that the game layout and functionalities replicate that of a real-life environment. As design progressed however, it was becoming clear that Enda's pursuit of virtual fidelity was compromising its usability. For example, he wanted the students to carry out all of the requisite tasks as one would do in real life. However, due to the nature of gaming, where an interface inevitably exists between player and game, it was clear that control specifications were necessary. To this end, the team listed the actions required for game tasks (such as picking up/leaving down items) and Dom designed corresponding control options (figure 5).

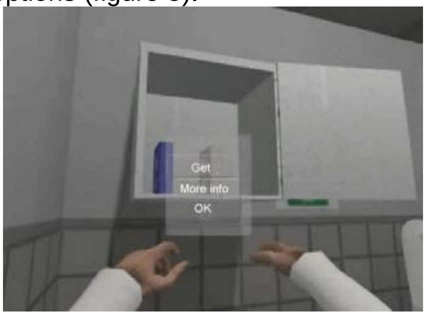

Figure 5. Pop-up allowing students to "get" an item or access additional information

While this functionality worked well for the simple actions required in most tasks, the hand-washing task presented a particular problem. From a pedagogical perspective, this task aimed to test knowledge of correct hand-washing procedures. However, it was clear that the functionality of the game would not permit a detailed examination of the physical hand-washing process: a compromise was needed to ensure usability and player engagement. Recognising this, Enda decided that assessing students' knowledge of the *sequence of steps* involved would be a reasonable compromise. Thus Dom devised functionality where students tell the game what they want to do rather than physically carrying out required actions (figure 6).

Figure 6. Functionality utilised for completing the hand-washing task

Thus it seemed that a compromise had been reached between replicating reality and achieving playability.

4.5 Conflicting priorities and adjusted expectations: a team of two halves?

While trust and communication between team members improved as the project progressed, many team interactions were marked by a tension which manifested itself in the contrasting objectives and priorities of the pedagogical and technical branches of the team. These priorities became particularly apparent during the aesthetic development of the game. Specifically, it had become obvious that many graphics inherited from the source engine were inappropriate for the game: for example, the environment was dark and grimy (figure 7) and the head chef resembled, in Enda's opinion, 'an Al-Qaeida suspect as opposed to a chef' (figure 8). More extensive artistic re-working of the source engine was required which necessitated recruiting a 3D artist.

Figure 7. The "grimy" locker room entrance

Figure 8. The head chef (originally a priest from Half Life 2) after initial "re-skinning" attempts

While inadequate knowledge of the source engine may have played a part in the decision not to recruit an artist to the team, it seemed that the "techies" had also underestimated the importance of graphic realism to the educational underpinnings of the game. As a result, it was also becoming evident that the priorities of the technical and pedagogical branches of the team did not correlate. As highlighted by Dom:

> making models is not on our priority list, nor do we have enough modelling abilities to do that (blog 10/07/06).

This conflict in priorities — whereby the pedagogical branch considered graphic realism to be key to the effectiveness of the game, while the technical branch were focussed on functionality — was not surprising considering the members' academic backgrounds. However it highlighted potential weaknesses of interdisciplinary team work when all members are not working to the same priorities and objectives.

Over previous weeks, it had become clear that our prototype would be "Phase 1" of a larger project. As expected, a prototype was ready by week ten, which as Dan warned, 'has more or less all of the functionality, [but] shouldn't be considered the final version'. While the technical branch may have adjusted their project objectives much earlier, the pedagogical side had certainly over-estimated what was achievable in ten weeks.

At the end of the project it was clear that we now needed to maintain momentum and formulate a strategy for fulfilling the original brief. To this end, a strategy for completing essential aesthetic and functional re-working was formulated. The game was eventually completed over subsequent months and piloted with target undergraduate students.

5. Evaluation and Discussion

When designing the game, the team had overtly discussed the importance of underpinning game play with pedagogical elements: in this regard, as the project progressed, natural affiliations emerged between the interests of the "techies" (who appeared more focused on game play strategies) and the "pedagogues" (who appeared to prioritise underpinning learning outcomes). Additionally, as the game design evolved, it became apparent that fidelity was also a key priority for all team members albeit for differing reasons: while the pedagogues associated it with higher levels of transfer, the techies prioritised fidelity due to the perceived role it played in engagement/immersion. (See figure 9.)

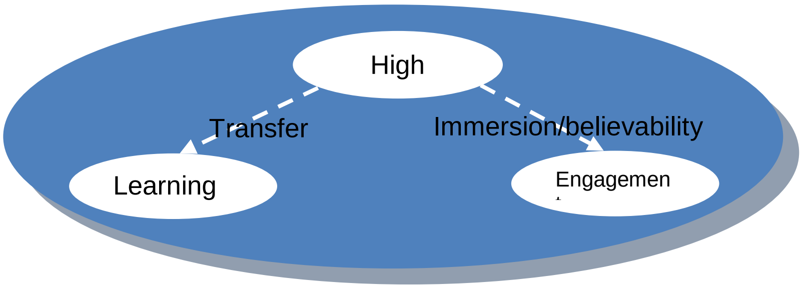

Figure 9. Dual rationale for high-fidelity approach

Thus the team attempted to integrate pedagogy, play and fidelity through various strategies. Firstly, the game narrative was structured around missions underpinned by learning objectives: a strategy which aimed to engage and educate through clear goals and timely feedback (Sweetser and Wyeth 2005). It was envisaged that this strategy would sustain challenge while allowing players to win in a risk-free environment: which is consistently identified as key to game design and an important facet of experiential learning (Beard and Wilson 2002, Klopfer *et al*. 2009). Secondly, the team used various narrative strategies to aid engagement and learning, including a narrative arc in which the player adopts a determining role, supported by micronarratives and narrative hooks (Dickey 2005). Finally, a high-fidelity approach was adopted on functional and visual levels (Alexander *et al.* 2005). By creating a highly realistic 3D environment, we hoped to (a) perceptually immerse the player in the game world (Lombard and Ditton 1997), (b) give students the opportunity to directly participate in, and experience, the workings of a real-life environment (de Freitas and Griffiths 2007) and (c) maximise transfer of knowledge and skills (Chalmers and Debattista 2009). Thus on paper, our design strategy appeared to integrate game play with pedagogy. However, evaluations of students' engagement with the game revealed an imbalance between these elements which compromised their engagement and motivation. In this regard, arguably the most prominent finding concerned the primacy of usability/playability to student engagement. In short, the team's over-emphasis on fidelity, and arguably pedagogy, during the design process compromised the playability of the game in several respects. On a physical level, while the team had feared that visual infidelities would compromise the believability of the game, this was not the case: indeed most criticisms centred around the usability issues that these graphic infidelities incurred, as opposed to their lack of believability. Additionally, when the team succeeded in affecting high-fidelity visuals, our approach caused usability issues. In particular, the narrow entrances which, apart from minor amendments, had replicated a real-life restaurant environment, made navigation difficult, thus undermining player engagement.

In sum, these findings reinforce those of Federoff (2002) and Brown and Cairns (2004) who state that usability and playability are key antecedents to engagement and they second the proposition that while highly realistic visuals may attract players in the initial stages of game play, they play a minor role in facilitating sustained engagement and immersion (McMahan 2003, Masuch and Rober 2005).

On an operational level, for the most part the team retained a high-fidelity approach, requiring students to complete tasks as they would in the real world. However, despite our hope that this would optimise believability and transfer, students' feedback highlighted significant associated playability issues. This was revealed in evaluations of two game tasks, both of which exemplified contrasting approaches to physical fidelity. In the hand-washing task, intricate procedural details were simplified to key stages. However the stacking task exemplified a high-fidelity approach, where students were required to put various food items into appropriate storage facilities, as they would in the real world. Interestingly, both tasks were most commonly cited in students' feedback: while the hand-washing task was praised, the stacking task was criticised. This indicates that game functionalities, do not need to replicate reality in order to achieve authenticity and believability, a finding which correlates with Masuch and Rober (2005) who suggest that *consistency* in the behaviour of world objects (as opposed to fidelity) is a more important predictor of engagement and immersion. This also reinforces King (2005) who argues that creating a less "authentic" depiction of the real world is sometimes necessary in order to achieve a more "playful" experience. In other words, playability is fundamental to engagement and in order to achieve it, a balance between simplicity and authenticity is required.

The question remains, would such simplification have impacted on the pedagogical effectiveness of the game? Considering previous research into simulation design — which suggests that physical fidelity is important for the acquisition of procedural knowledge/skills, while functional fidelity is important for the construction of conceptual knowledge (Alexander *et al*. 2005) — simplifying game operations for the stacking task is unlikely to have had a detrimental impact on students' acquisition of learning objectives. Indeed, as suggested by Kiili (2007) such selective extrapolation may have enhanced learning by maximising usability and avoiding cognitive overload. While this reinforces the need for carefully balancing fidelity with playability, it also highlights the need to consider the *level* and *type* of fidelity required in light of underpinning learning objectives. Although common to simulation design theory (Alexander *et al*. 2005), due to our unfamiliarity with this specialised area, the team made the fundamental mistake of equating high fidelity on all levels with authenticity and thus transfer.

On a functional level (that is, the extent to which the game acts like the real world (Alexander *et al.* 2005)), the team had adopted a similar high-fidelity approach in the belief that this would enhance authenticity and learning. However, once again this approach compromised playability and engagement through its omission of features including a map, scoring mechanism and so on. This correlates with Davies (2002) who warns that the "trap" of over-emphasising replication in serious game design can result in a lack of features which enhance both playability and instructional support. Consequently, as Davies (2002) and King (2005) suggest, it would seem that departures from functional and physical fidelity are sometimes necessary in order to enhance instructional support, playability and engagement in serious games.

Thus to summarise, despite our intentions, the team had largely failed to achieve an effective balance between play, pedagogy and fidelity in Serious Gordon. Ultimately, our prioritisation of fidelity — which was underpinned by the dual objectives of engaging and educating players — led to an imbalance which compromised playability and undermined the "fun" experience of game play. As a result, one might reasonably surmise that the pedagogical objectives of the game were also undermined.

Returning to my original research question — which aimed to explore the links between disciplinary-based perspectives and the balancing of design elements in serious games — one can identify how the team's (in some cases conflicting) understandings of, and perspectives on, the game in question led to these design weaknesses. Specifically, fidelity (both physical and functional) was one component which all parties were agreed should constitute high priority in the design stakes. Thus, the team had essentially reached a consensus (or achieved a communal objective) in this regard, despite the fact that individuals' understanding of the *role* of fidelity may have differed. From this analytical viewpoint, one might argue that the team's single communal design objective became prioritised during the design process, at the expense of other key elements. This suggests that, for teams undertaking such projects in the future, developing shared understandings of *all* key design elements and their interrelationships — specifically play, pedagogy and fidelity — when undertaking such projects is of crucial importance.

6. Conclusions

It is generally acknowledged that, in order to create a successful serious game, it is important to 'get the correct balance between delightful play and fulfilling specified learning outcomes' (de Freitas 2007, p.5). Recent literatures have also highlighted the concept of fidelity in serious games, with different parties exploring its role in facilitating player engagement, immersion and learning. Previous research has highlighted the difficulties involved in balancing these components in serious game design (Aldrich 2005, Harteveld *et al.* 2010, 2011). This study adds a new dimension to these established difficulties by illustrating the significant impact which disciplinary perspectives can have on the design process. In this regard, it has shown that an *interdisciplinary* and "unbounded" knowledge of the field of serious games, specifically the relationship between engagement, learning and fidelity, is important. Additionally, and perhaps most significantly, this study has shown that a *shared understanding* of the project — or a communal motive — is essential in order to achieve an effective balancing of design elements. While on paper the Serious Gordon team comprised most of the skills required for serious game design (including pedagogical expertise, subject matter knowledge, game design and development experience), our lack of shared *understanding* (resulting primarily from disciplinary-based foci and interests and a lack of experience in designing serious games) led to unclear objectives and conflicting expectations for the project. This not only caused communication difficulties during the design process but also compromised the end product. Thus while reinforcing established difficulties involved in balancing play, pedagogy and fidelity in serious game design, this study adds a new dimension to these difficulties by illustrating the significant impact of participants' backgrounds and interests on the design process and outcome, and the importance of building shared expectations and understandings in this regard.

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